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Use of Er:YAG Laser for Benign Skin Disorders

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Background and Objective: **The Er:YAG laser is of special interest in dermatology and cosmetic surgery since it ablates and cuts tissue with surgical precision with minimal collateral thermal damage due to the wavelength of the Er:YAG radiation (2,940 nm), which is strongly absorbed by liquid water in tissue. The study was designed to establish optimal laser parameters for treating various skin disorders.**
Study Design/Materials and Methods: **Sixty-four patients were treated for benign skin disorders: seborrhoic warts, plane warts, milia, xanthelasma palpebrarum, hidradenoma, chloasma, senile lentigo, epidermal naevi, actinic keratosis, fibroepithelial papillomata, scars. The lesions were irradiated with single pulse laser energies 100–1,000 mJ, repetition rates 2–10 Hz, and spot diameters 2–8 mm.**
Results: **Epidermis was effectively removed on a layer-by-layer basis. For the ablation, energy densities higher than 2.5 J/cm^2 were required. If bleeding appeared, the hemostatic effect was achieved by irradiating the bleeding surface with few Er:YAG laser pulses of lower power density (0.5–1.5 J/cm^2). Healing was excellent and without apparent scarring.**
Conclusion: **It was established that Er:YAG laser with properly selected parameters offers a tool for tissue ablation and/or coagulation. The Er:YAG laser was found to be a perfect option for effective treatment of benign skin disorders. Lasers Surg. Med. 21:13–19, 1997.**

Key words: **Er:YAG laser; layer-by-layer; lesions; penetration depth; skin ablation; skin coagulation**

INTRODUCTION

The ability to control epidermal vaporization depth with minimal damage to the dermis is a prerequisite for successful scar-free removal of benign epithelial skin changes [1]. Lasers were introduced to dermatology soon after the invention of the laser (1960) and since then have found wide acceptance and use by providing evidence of their extraordinary ability to treat precisely and effectively a number of skin diseases that were previously unmanageable by other medical and surgical methods [2]. For this reason, there are now several different types of lasers being used for a wide array of dermatology conditions [3].

The Er:YAG laser emits an infrared light with the wavelength of 2,940 nm that is strongly absorbed by tissue water. Its small penetration depth combined with the high power of the short light pulse enables the Er:YAG laser to ablate and cut soft tissue with surgical precision, similar to that of conventional scalpels. The penetration depth of the Er:YAG laser beam is limited to a thin (few micrometers) upper layer of tissue. Soft tissue incisions with Er:YAG laser are as quickly healed as the ones performed by scalpel [4], and bleeding is minimal [5,6].

MATERIALS AND METHODS

In this study, 64 patients were treated with the Er:YAG laser (Fotona Skinlight Surgical La-

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ser, model Twinlight 220A, Ljubljana, Slovenia) for different epithelial changes. The diagnosis of those patients were as follows: seborrhoic warts, plane warts, milia, xanthelasma palpebrarum, hidradenoma, chloasma, senile lentigo, epidermal naevi, actinic keratosis, fibroepithelial papillomata, and scars. The lesions were removed on a layer-by-laser basis. The laser was used as an ablation tool.

The lesions were irradiated with single pulse laser energies between 100 and 1,000 mJ, repetition rates between 2 and 10 Hz, and pulse duration between 0.2 and 0.4 ms. The equipment allowed variation of spot diameters between 2 and 8 mm. The diameter of the laser spot was determined and easily controlled by the laser handpiece attachments. Spot sizes used depended on the size of particular lesion. Energy densities between 0.5 and 7 J/cm^2 were applied to the tissue. Higher energy densities (2–5 J/cm^2) were used for tissue ablation and lower energy densities (~1 J/cm^2) for tissue coagulation.

Some of the treatments were performed without any anesthesia; in some cases, a 1% Xylocain injection subcutaneously was used. Local anesthesia was used for deeper and larger lesions, especially on the face and in the periocular region. No special pretherapy was ordered. After the laser treatment, a combination of betamethasone dipropionate and gentamicin sulfate ointment was applied for 5–7 days. The patients were advised to avoid exposure to strong sun for 2 months after the treatment. Photos were taken before the laser treatment, immediately after it, 1 week later, and 1 month after the treatment. Follow-up periods were up to 15 months.

RESULTS

A total of 267 skin disorders (64 patients) have been treated with Er:YAG laser. The results are summarized in Table 1. Energy densities used were up to 7 J/cm^2 with the exception of hyperthrophic scars, where the applied energy densities were much higher. The number of laser passes needed for lesion removal depended on the depth of particular lesion. In most of the cases, only one session was sufficient. Hidradenomata, acne scars, and hypertrophic scars required two or more treatments. Follow-up periods range between 1 and 15 months. The average mean follow-up period is 7 months. The degree of lesion clearance is in almost all cases 100%, with the exception of chloasma (80%), hidradenomata (70–95%), acne scars (30%), and hyperthropic scars (50–95%).

No hyper- or hypopigmentation was observed in reported cases. No infection was observed postoperatively. Epithelisation time was between 7 and 10 days. Redness persists up to 3 weeks in all cases with the exception of scar and wrinkle treatments, where redness can persist up to 2 months.

The patients with superficial lesions described discomfort during the laser treatment as mild. Epidermis was effectively removed on a layer-by-layer basis, and bleeding appeared if the upper dermis had been reached. The bleeding was stopped after completing the treatment by irradiating the bleeding surfaces with few Er:YAG pulses of lower power density (0.5–1 J/cm^2). At those lower power densities, the Er:YAG laser does not ablate the tissue, but coagulates very thin surface layer [4]. Healing was excellent and without apparent scarring and achieved very good effects after only one treatment in most cases (Figs. 1–3).

DISCUSSION

Laser ablation of superficial skin lesions offers many advantages over conventional techniques. However, many of today's lasers induce unwanted destruction of viable tissue adjacent to the treated tissue. This results either in scar formation or poor wound healing. Water and its absorption characteristics are among the most important factors that influence the process of tissue ablation, because water is significantly present in soft as well as in hard tissue; water-weight percentage of skin is ~ 70%. Due to the absorption coefficient of Er:YAG in water, which is significantly higher than that for any other visible or infrared laser, the penetration depth in water is ~ 0.001 mm [7–9]. This compares with the CO_2 laser wavelength, which has a penetration depth of 0.02 mm. The reported short pulse CO_2 thermal damage is 0.075–0.150 mm, its vaporization depth 0.07 mm [1], and the reported normal mode Er:YAG thermal damage is only 0.01–0.05 mm [10].

Laser pulse durations between 0.2 and 0.4 ms were used in all our cases. Variation of pulse duration within the stated range had no noticable effect on tissue. An acousto-optical experiment was performed during the preclinical stage of our study. Laser pulses with different pulse duration and energy density were applied in vitro on pig's

TABLE 1. Benign Skin Disorders Treated With Er:YAG Laser

Lesion type	Energy/ pulse [mJ]	Spot dia. [mm]	Energy density [J/cm²]	No. of laser passes needed per lesion per session	No. of patients	Total no. of lesions	No. of treatments required	Follow-up: mean [months]	Follow-up: range [months]	Degree of lesion clearance [%]
seborrhoic warts	300–500	3–5	4–5	3–10	8	20	1	8	1–15	100
senile lentigo	250–500	3–5	4–6	2–5	5	10	1–2	10	1–15	100
epidermal naevi	250–300	3–5	3–4	3–5	9	18	1	6	3–15	100
chloasma	350–500	5–7	1.3–1.7	2–5	2	2	1	5	1–9	80
milia	100–300	2–3	3–4	2–5	4	78	1	8	5–14	100
xanthelasma palpebrarum	450–550	3–5	5–7	5–15	8	32	1	3	1–10	100
hidradenoma	400–600	3–5	5–7	5–10	5	48	2–3	5,5	2–11	70–95
plane warts	350–500	3–5	4–5	3–5	6	8	1	8	4–12	100
actinic keratosis	300	4	2.4	2–4	6	8	1	13,5	12–15	100
fibroepithelial papillomata	300	4	2.4	2–5	3	21	1	4,3	3–7	100
acnae scars	100–500	3–7	0.5–1.5	1–3	2	2	1–2	8	5–11	30
hypertrophic scars	500–900	2–5	10–30	5–15	6	20	3–4	5,3	1–9	50–95
total:					64	267				

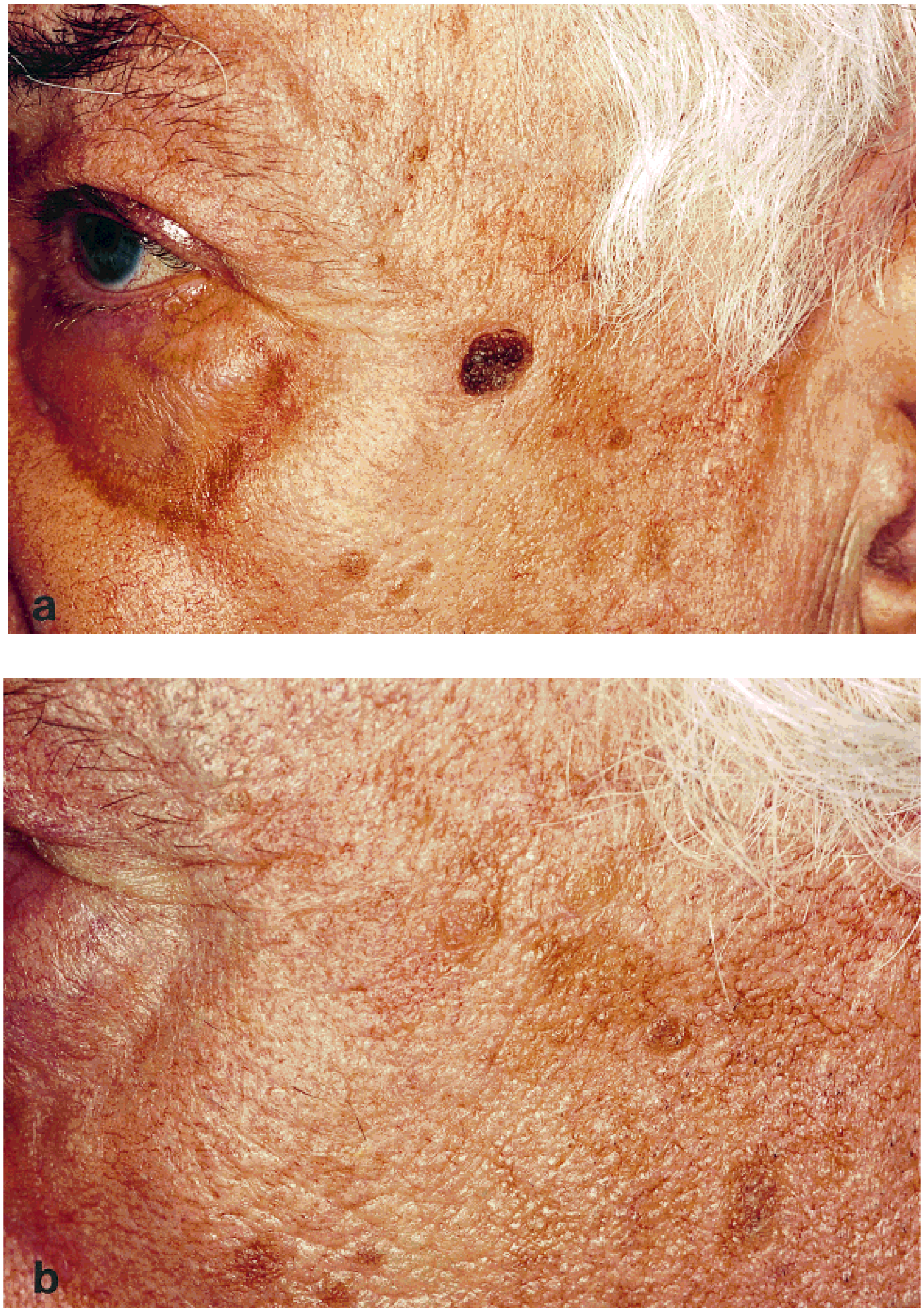

Fig. 1. Verruca seborrhoica papillomatosa: before laser treatment (**a**) and 7 days after (**b**). Applied energy: 400 mJ, number of laser passes: 8.

skin. Laser pulses between 0.1 and 0.4 ms had all the same ablation threshold, which was ~ 1 J/cm^2.

For our patients where the benign epithelial disorders were limited to epidermis, the effect of Er:YAG laser ablation was excellent. No clinical evidence of infection was observed, healing was quick, and without apparent scarring. Results were remarkable as well in the cases of pigmental lesions, with pigment located along basal membrane or only partially in the stratum papilare of dermis. Intradermal nevi, which are melanocytic lesions, have not been treated. We have limited treatments to epidermal nevi. Haemostasis was

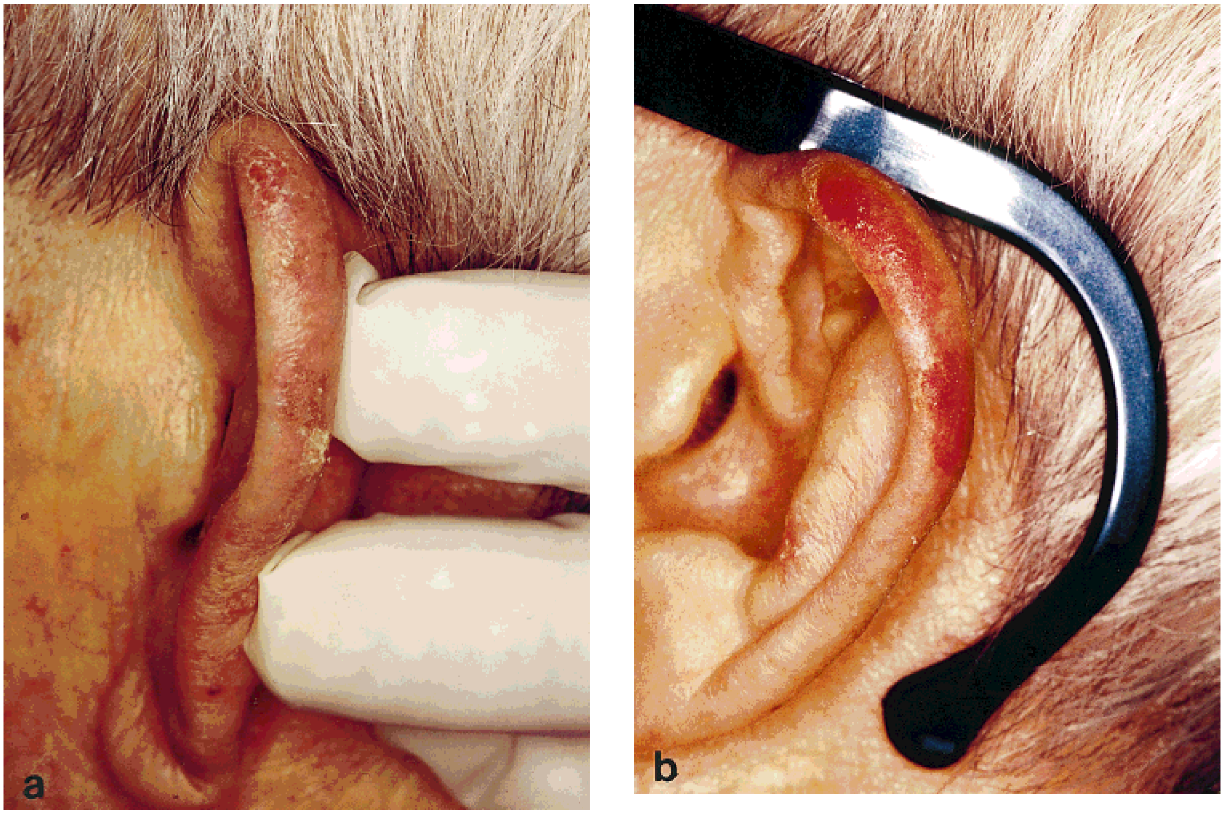

Fig. 2. Keratosis actinica: before laser treatment (**a**), immediately after (**b**), and 10 days after (**c**). Applied energy: 200 mJ, number of laser passes: 2.

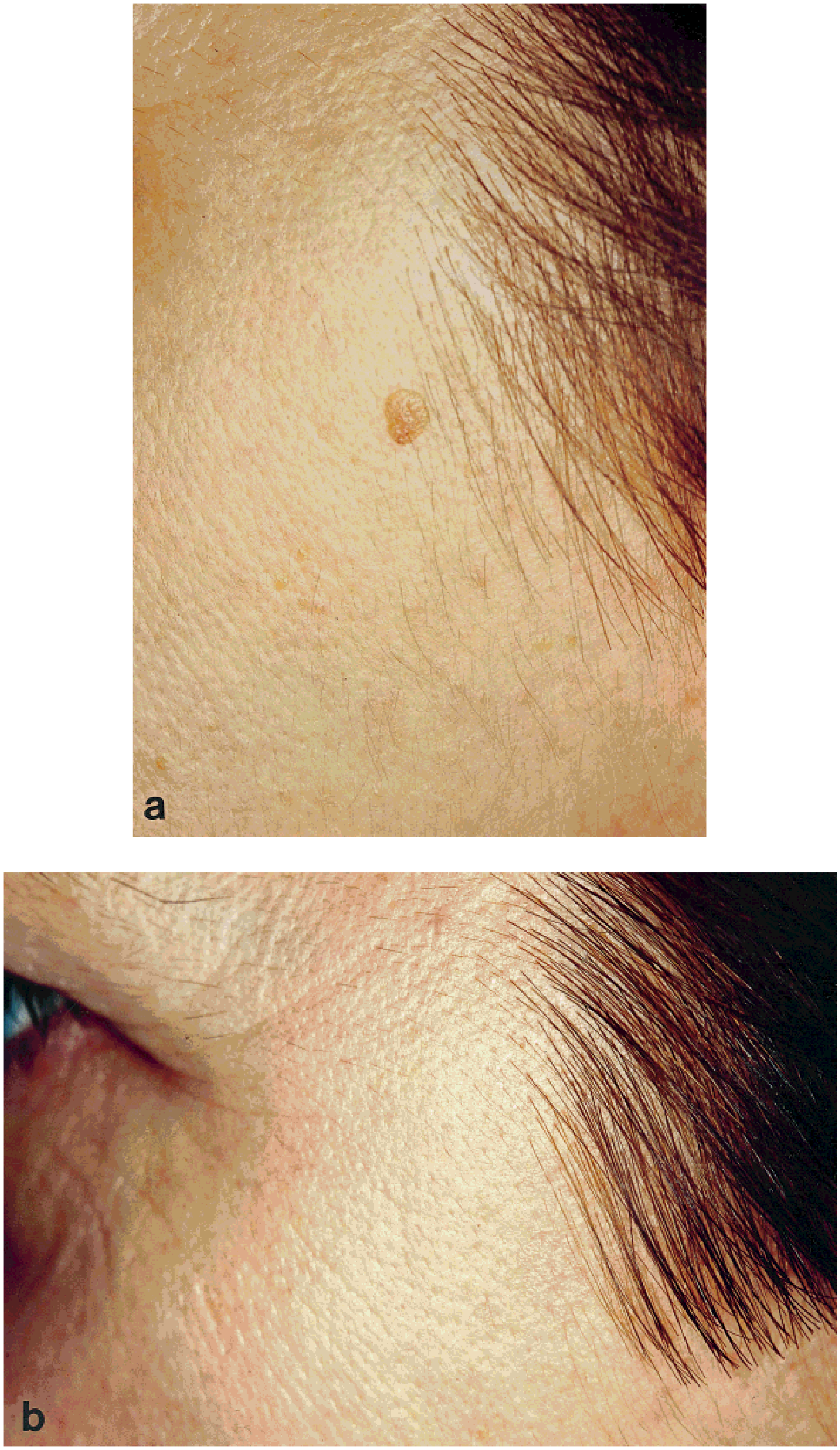

Fig. 3. Epidermal nevus: before laser treatment (**a**), and 3 months after (**b**). Applied energy: 300 mJ, number of laser passes: 4.

achieved by application of the Er:YAG laser in the coagulation mode (energy densities just below the ablation threshold). Haemostatic effect is sufficient to seal thin blood vessels and is not as strong as in the case of CO_2 laser [11, 12]. If low energy density (below or around ablation threshold, ~ 1 J/cm²) laser pulses are applied to the tissue at higher repetition rates, strong coagulation effects can be observed.

In conclusion, the Er:YAG laser is easy to use, enables high precision of the skin ablation procedure on a layer-by-layer basis, and the depth of the ablation per laser pulse is easily controllable without risk of tissue charring. Results are good, patient discomfort is mild, and the recovery period is relatively short. The ability to use the Er:YAG laser in the ablation or coagulation mode (as needed) is its unique advantage. We found that laser parameters (particularly energy density) are very important and when properly selected the laser offers a tool for tissue ablation and coagulation, what gives high potential for applications in dermatology and aesthetic surgery.

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